Advanced Green Manufacturing Systems
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Lecture - 31
Design for Environment (Part 3 of 4)

Good morning welcome back to the course. I am discussing Design for Environment in this lecture. We have discussed what is waste management first of first we saw what is the need of design for environment, scope of this, then we saw what is waste management. Now I like to take it forward I like to discuss what are the levels of design in this.

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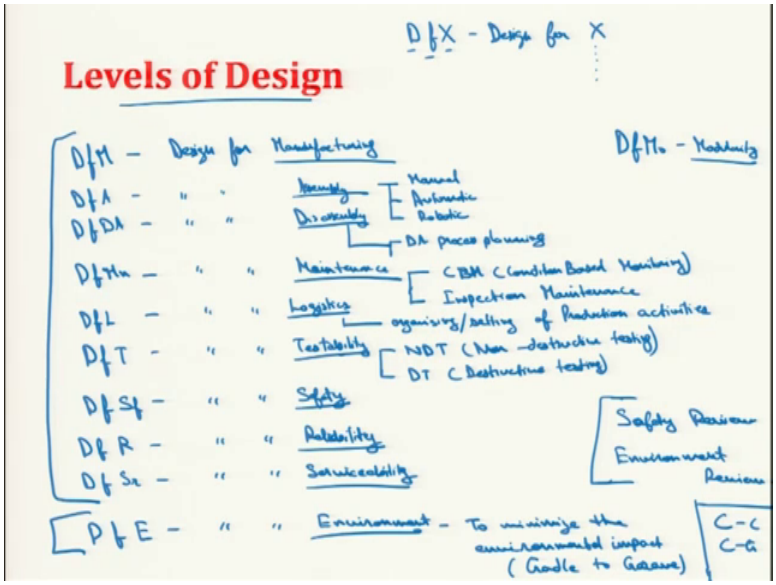

Essentially I like to discuss what is D f X. This is actually design for X, design for X. What is this X we will discuss. We have now come up with the term design for environment which were discussing in this lecture design for manufacturing and design for assembly were being discussed way back. And, this X as multiple names in it I will put D f M the very basic concept that came into existence that was design for manufacturing.

What happen before the idea was just taken from the customer the idea was replicated or generated and the designer would have just design in his mind without considering what will be the manufacturing concerns in that. Now production manager felt such an difficulties in implementing what designer wanted into do. So, there came the term this D f M, Design for Manufacturing design for manufacturing implies while designing, we need to consider that what we are discussing what we are trying to implement is it actually workable or not. What are the resources available, what are the various processes available in our industry, materials, availability, then the time that would it would to take all those things that is design for manufacturing.

While designing we consider the manufacturing scenario this is also known as concurrent engineering in some way. So, similar to this we have D f A that is Design for Assembly; design for assembly as it is said design for manufacturing design for assembly is essentially, we design the product for assembly the whether it could be a could be assembled or not. I will just also put D f M; D f M o actually D f M o, we can put when I will discuss about the levels of design for environment this is design for modularity.

What happens in modularity? We produce the production in modules. Modules means products produced in various components which can be put together and the fore component product is complete like you have your automobiles, you can get them serviced, you can get the carburetor replace, you can get the various nuts and bolts replace. This is modules designing the thing in module like a chair design with thought of chair can be one piece if we make it of a polymer or of a plastic.

It can be having modules like back base seat backrest, it is pedal foot pedal etcetera that can be different components that can be put in one final assembly that is design for modularity. In that way what happens if one component went wrong, we can get that replace. We do not have to replace the whole assembly or the whole product in that case. That is design for modularity.

Design for assembly as here essentially what is important is design for disassembly. Design for assembly is that any product that is produced can be assembled, but disassemble how easy it is to disassemble the product and then repair or work on it that is very important. That is another level of design ok. In design for assembly, it can be manual as it can be manual assembly, it can be automatic or it can be robotic right. So,

this is design for assembly there are certain guidelines which are given by such an such assembly and for disassembly for this disassembly, we need to have disassembly process planning.

This is important. After this we have design for maintenance. The design for assembly and design for disassembly has design for maintenance inherited in it. Design for maintenance is we need to first let me put maintenance design for maintenance. In this we have certain maintenance models that maintenance elements maintenance, concepts or they may be inspection maintenance or the certain terms known as CBM that is condition based monitoring ok. Then we have inspection maintenance I can also put this. So, these are certain attributes of the design, then the levels of design. Next we can have the f L which is design for logistics that is the organization organizing or setting of production activities.

That in which orders or what is the logistic, what is the material handling, what is the total material handling time, how the material handling equipment has to move all those things. Similarly we can have design for testing that whether the testing is possible or not again for maintenance. It can also come in maintenance design for maintenance or its already covered testing. I would better put testability that do we have to conduct NDT that is non destructive testing or does it have to be completely destructive testing. Like if we know there is a test automobiles known as crash test the cars are made to run at the maximum speed that is given in the engine power and that made to crash with the wall that is rigid wall in the car crashes and the certain components shutters into pieces and it all spread.

So, what is the total damage that has happened to the automobile, then this is total destructive testing. To be very safe, we will discuss that in design for environment. We will have strategy that I will discuss in which the two reviews; one is safety review, another is environment review. So, these two go hand in hand was we will just discuss in the forthcoming slides here. So, other than this is because I have put safety I can put design for safety here as well design for safety is this is done. So, that the product is safe to use and the companies not held liable for any damage the customer or to the product, then design for r this is design for reliability right.

Send design for I would can even say I can put safety as S f and Design for Serviceability, S r this is Design for Serviceability that after sales service is that when you provide to the customer is the after sale easy or can it be offered in a reasonable cost to the company. So, what is after sale services is because customers want to pay much for their after sale services like I discuss life cycle costing in. Life cycle costing if you call the certain components are one is the purchase of the product when you purchase the product like you purchase a mobile phone that is costing rupees ten thousand. But if you [net/need] need to get that serviced the service centre is not available locally, if to go to some other city may be hundred kilometers from this place or you have to send the mobile in a courier to the company at different place. So, that is serviceability.

Serviceability is not available locally number 1, number 2 what is the cost to the customer and cost to the company for serviceability is the company spending much. Whatever the company is spending that has to in turn go to the customer itself. So, customers would like to see the life cycle cost that, I am purchasing this product using the purchasing the product. Using the product and after that the replacement or disposal of the product what is the total cost customers do consider that. For that design for serviceability comes into play. After that the next level of design, we have here is design for E that is Design for Environment that is more focused in this lecture and we had been discussing this.

This says again to reduce or to minimize to minimize the environmental impact that is impact completely from cradle to grave, you can discuss about or you can actually read about what is cradle to cradle, cradle to grave. What are these terms? So, cradle to grave means from the very initiation from that session of all to the final disposal. So, this is all to minimize the effect throughout the life cycle through serviceable life of the product that is to minimize the environmental effect throughout the life it is the service life. It is after use life and before use manufacturing what is the overall environmental harm that is happening that we need to see.

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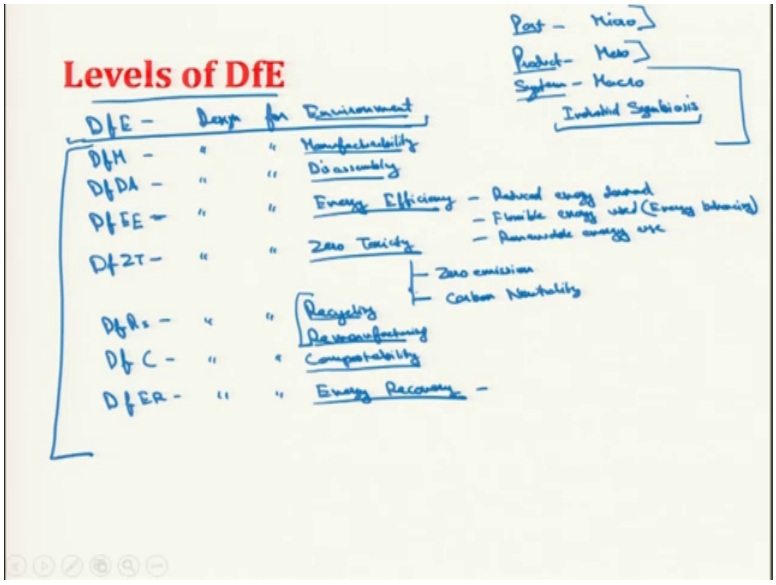

Next is levels of design for environment. We have D f E Design for Environment. Now it has also certain levels. First level I can see it can be at product scale, it can be at I would put it before part scale or it can be at the system scale. Next part scale and product scale as we have discussed in value engineering we can just focus on one component or one of the subassembly of the part like you can say the chassis of an automobile that is a subassembly that we can work on and try to improve the environmental impact you know total life cycle environment affecting that. So, product is the complete automobile what is the design of the complete automobile. So, I would like to you to see a video that is developed by Boeing aircraft manufacturing, this is a 2 minutes video; they are working in the systems view point.

The system view point that in the system the overall design of the aircraft how they are now considering the design for environment. When the air craft was manufactured may be 5 decades before, it was just they have manufactured based upon the safety review. Safety review is that air craft have to be safe and safe means in a way whenever we design the metal whatever we select these days actually composite sides comes into play generally, it was designed from duralumin which is an aluminum based alloy. So, factor of safety is given like 4 times if for instance the strength required is just pick the units mega Pascal. The strength required is 1000 mega Pascal's factor of safety is given 5 will decide for thousand into 5 5000 mega Pascal's

So, this is the factor of safety that is given that gives the overall design or makes the overall design a little bulky. So, it has to be very careful factor of safety as the a safety is

completely there and after the product design become very heavy or very costlier the cost was only criteria before. Now recyclability of the components those are chosen is very important. We will see this in a video. So, let us see this video and we will then discuss about design for environment.

It has approximately 3 million parts and before it ever takes off Boeing engineers already know how those parts will affect its flight. Along with its environment from raw materials and production methods to fuel efficiency and aircraft retirement Boeing is designing jet liners to improve every aspect where use and environmental performance. Airplanes have very long in service life spans. My job is to look for ways to continue improve the environmental performance of those products over their entire life cycle.

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When jet liners were first built, there was not much thought given to materials components or even whole aircraft once their service lives were over. Often 30 or more years after, they were originally manufactured, but that is all changed.

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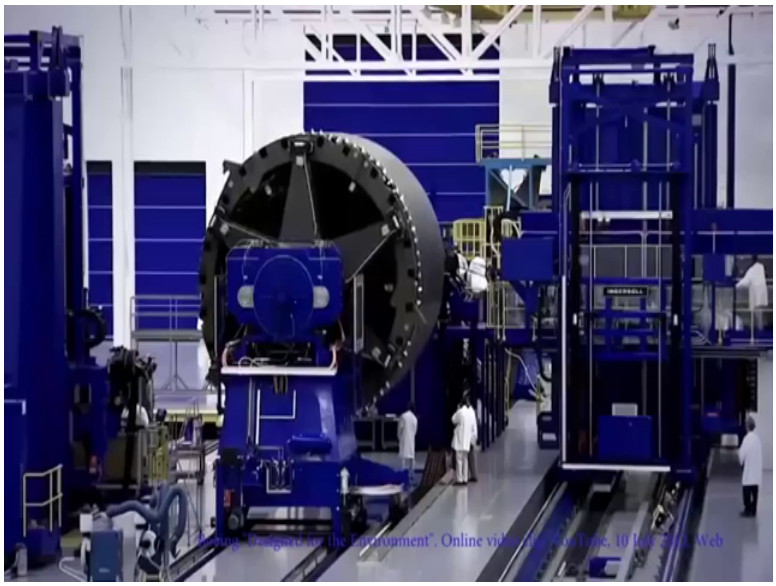

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Boeing is now building entire airplanes with recycling in mind take composite wing and fuselage structures for example. The 787 is made of composite structure which its what makes it lighter weight and makes it significantly more fuel efficient than the airplanes that they replace.

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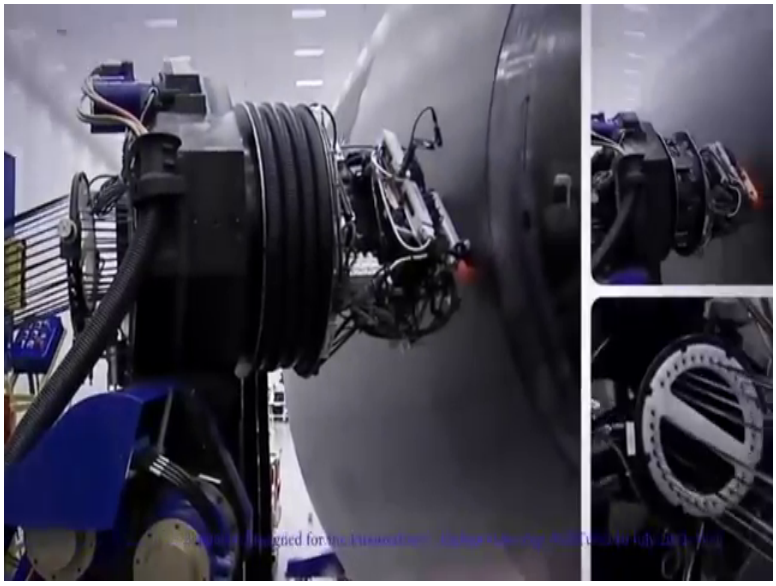

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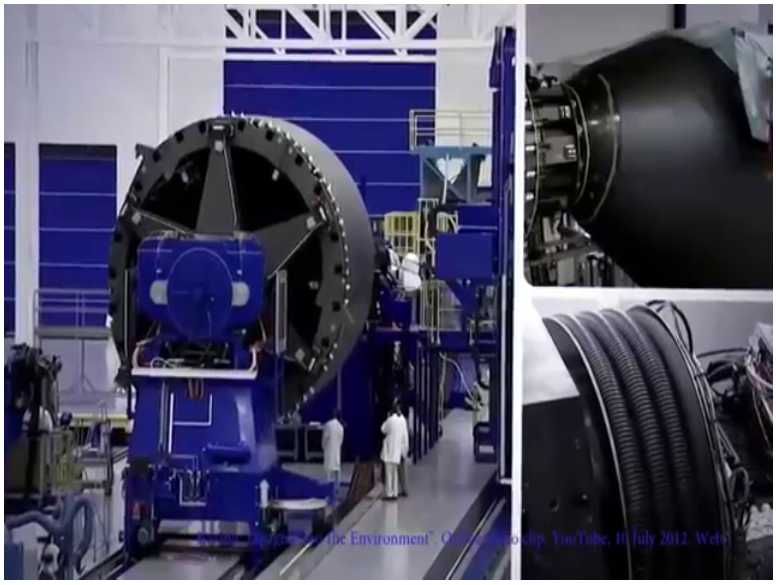

With composites we have been working very hard with the industry to understand how to preserve carbon fiber.

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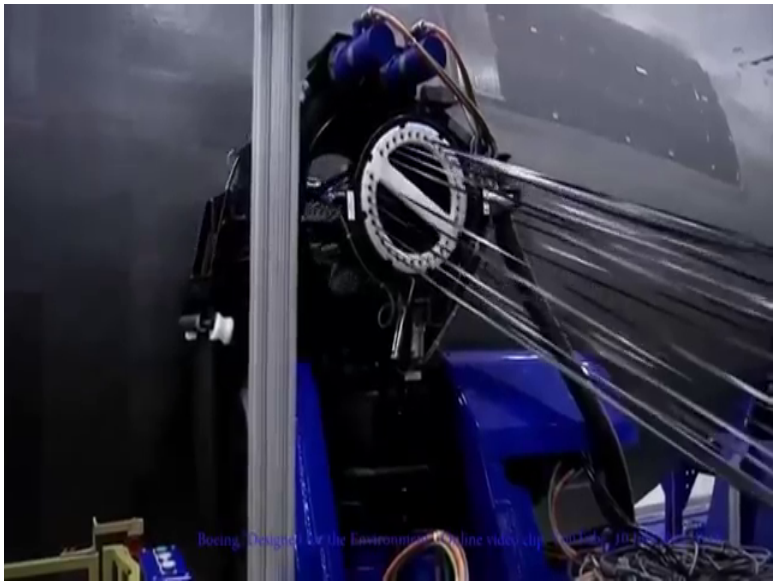

Because once you can recycle the carbon fiber, you can put it into many other applications and much lighter costs and much less energy than it would take for raw material use. However, designing for the environment goes well beyond high tech materials such as carbon fiber. It includes better recycling approaches for the most ordinary materials like aircraft carpeting.

We were surprised to find out how often carpet is turned over in an aircraft. So, over the 20 to 30 year lifespan of one single aircraft tons of carpet can go to landfill.

That is why Boeing is helping airlines replace small sections of wooden carpets with recyclable carpet squares. If there is a stain or a spill, you can remove one carpet tile and replace it with a fresh tile and it fits right in an any, it is seamless. We love it, our customer loves it and its better for the environment.

So, that is a win-win-win for all. What really makes designing for the environment important is the scale it represents. Boeing produces more than 48 large commercial jetliners a month. So, an improvement in an airplanes design can be reflected in thousands of planes in just a few years.

There is nothing simple about aircraft. The real challenge is that make an airplane more recyclable or must set more sustainable is that we need everyone was anything to do with airplane to begin you think in a more sustainable way.

Now you have seen is brief introduction about what the companies are doing for design for environment like Boeing aircraft is doing. Now, let us see that when it is part level it is also known as micro level. When it is at system level it is known as macro level we are talking about advanced green manufacturing systems. So, we are not more concerned about the overall system from working on a single part; yes mechanical people can do that on the product. Then that can also be dealt by mechanical or other allied fields, but we are more concerned on system.

In between we can have Meso. Meso is something when we talk about the entire product or may be entire factory as well complete factory can also be meso. System is the overall the total supply chain other than the factory who are the suppliers, who are the vendors or suppliers and who are the customers. So, all that system in which many things comes into play like the previous version of this course we discussed about the term known as symbiosis.

That is industrial symbiosis in which various byproducts of one industry can be used as a raw material for another industry. So, this cycle can help to mitigate some of the environmental impacts if we do not have the allied or the supporting industries, we do

not use the byproducts, that has to be transported from other place. So, we have an industrial parks where this byproducts from one industry like heat generator from one industry for instance the treatment of lubricants that when that happens exothermic reactions are there which generate heat that heat can be used by a neighboring company which can use it in the boiler to heat water or to use that for their purpose. So, this is the overall system the industrial system.

This is part this is product or factory. So, these are the levels of D f E other than these with D f M actually is always there this is design for manufacturing or I will put design for manufacturability here. D f M and Design for Disassembly comes as the components of design for environment right. These are just discussed in the previous slide. Other than this we have design for E E, this is Design for Energy Efficiency. Design for energy efficiency this is for the reduced energy demand during use of a flexible energy use reduced energy demand, then is flexible energy used.

If you know the concept of line balancing line balancing is we balance the line the assembly line in a way that the worker distribution is even. No worker is idle for any point of time like for instance. I show you something about the distribution of worker etcetera when I will discuss about the factory design in the simulation. What is the essentially line balancing? It is a for instance, we have 4 workers and 10 machines; there a setup and processing time set up time is when the worker is actually busy working on the machine processing can be automatic.

When he is doing the setup he can be the workers; 4 workers can be distributed to 10 machines in a way that no machine is idle or it is a minimum idle time. It is not ideally possible that no machine is idle or worker is idle the minimizing the idle time for the machines and a work the worker has to be busy for the maximum number of possible time and the machines also have to be the same.

So, this is line balancing between workers and machine. Similar concepts are being applied to line base l balancing between the energy and machines. For instance we have the load capacity of the factory, we can say for this time span this machine that is consuming maximum energy or heavy energy is working for this time other machines can do setup of also the other time when these machines this set of machines are working or doing operating, this can you set up. That is line balancing in the terms of energy that

is known as energy balancing; that is here in flexible energy use right. So, also as we discussed energy efficiency, we cannot miss renewable energy renewable energy use right. After that we can design for Z T, we can put these terms, like this Z T is Zero Toxicity.

Design for zero toxicity implies there should be minimum pollution or the toxic chemicals which are harmful to the workers those should be minimum ok. This is zero emission and this is carbon neutrality right. We actually conducted a study in IIT Kanpur where we consider the short term and the long term goals. I will try to bring that presentation to you in which we took the error sole that is produced during machining in the machine shop as one of the factors to be mitigated. So, in that zero emission; however, is not possible again I would say, but we can minimize emission that is that harms the worker. So, that is the short term goal again long term goal is the fluid that we use because in machining the cutting fluid is there and when that gets into the lungs of the operator that harms their health.

This is deteriorating their health and in the long term in certain years, they can have the chronic diseases. So, those are not good. So, those are worked upon. So, next we can have design for Rs, design for certain Rs is not Rs certain Rs that is designed for recycling remanufacturing and so on. This we have discussed in the previous lecture. Now next that can be design for compostability. This means what is the compostability; how easy it is to dispose of the product when we finally, had to dispose off or the byproducts which are produced during the manufacturing; how easy it is to deal with them. So, this is design for compostability.

Similar to this we have design E R that is Energy Recovery. This is for the safe insanitation of residues and for composting of the residues those are produced in manufacturing. So, these are the levels of design for environment the people are working with this and certain other levels are coming. So, we have discuss the levels of design and levels of design for environment I will have to discussed about the implementation strategy of design for environment in the next lecture which is a case that is taken by one of the researchers and we will see how safety review and design review go hand in hand. So, let us meet in the next lecture.

Thank you.